Massachusetts Urban Forestry Program

The Citizen Forester

October 2006 No. 108

Trees as Biotechnology to Improve the Environment– Dr. David Nowak, USDA Forest Service

(The following article is adapted from "Institutionalizing urban forestry as a `biotechnology` to improve environmental quality" by Dr. Nowak, 2006.)

Urbanization concentrates people, materials and energy into relatively small geographical areas to facilitate the functioning of society. Urbanization often degrades local and regional environmental quality as natural landscapes are replaced with anthropogenic materials. Byproducts of urbanization (eg., heat combustion, and chemical emissions) affect the health of the local and regional landscapes, as well as the health of the people who reside, visit and/or work in and around urban areas.

In the lower 48 United States, percent of land classified as urban increased from 2.5% in 1990 to 3.1% in 2000 (44,834 km^2), an area about the size of Vermont and New Hampshire combined. Patterns of urban expansion reveal that increased growth rates are likely in the future (Nowak et. al., 2005 a,b). Urban land is projected to increase from 3.1 % in 2000 to 8.1 % in 2050, an area (392,000 km') greater than the size of Montana. By 2050, four states (Rhode Island, New Jersey, Massachusetts, and Connecticut) are projected to be more than half urban land (Nowak and Walton, 200 5).

Urban vegetation, through its natural functioning, can improve environmental quality and human health in and around urban areas. These benefits include improvements in air and water quality, building energy conservation, cooler air temperatures, reduction in ultraviolet radiation, and many other environmental and social benefits (Nowak and Dwyer. 2000). Properly designed and managed, urban vegetation can be used as a natural "biotechnology" to reduce some of the adverse environmental and health effects associated with urbanization. With the extent of urbanization expanding across the landscape, there is an urgent need to incorporate the effects of urban vegetation on reducing the adverse effects of urbanization into long-term planning, policies, and regulations to improve environmental quality and human health.

Methods

To incorporate the effects of urban trees in meeting environmental standards, the impacts of trees on the environment need to be quantified. The urban forest functions that appear to be most critical to environmental quality and associated regulations are tree effects

on air and water quality, and carbon sequestration. To quantify these urban forest effects in various cities, the Urban Forest Effects (UFORE) model was used. The UFORE model uses standardized field data from randomly located urban forest plots and local hourly air pollution and meteorological data to quantify urban forest structure, functions, and values (e.g., Nowak et al., 2000, 2001, 2002a, b, 2005a, b; Nowak and Crane, 2000, 2002). The model currently quantifies: (a) urban forest structure by land use type (e.g., species composition, tree density, tree health, leaf area, leaf and tree biomass, species diversity, etc.); (b) hourly amount of pollution removed by the urban forest, its value, and its associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (< 10 um); (c) hourly urban forest volatile organic compound (VOC) emissions and the relative impact of tree species on net ozone and carbon monoxide formation throughout the year; (d) total carbon stored and net carbon annually sequestered by the urban forest, including its value to society; and (e) effects of trees on building energy use and consequent effects on carbon dioxide emissions from power plants.

To date, urban forest structural data (e.g., tree species composition, number of trees, trees size, health) have been or are being collected and analyzed with the UFORE model for about 30 cities, with about one-third of the analyses occurring in cities outside of the United States - e.g,, Beijing, China (Uang et al., 2005); Fuenlabrada, Spain (Lozano, 2004); Santiago, Chile (Escobedo et al., 2004); and Toronto, Ontario, Canada (Kenney et al., 2001). From this basic field data, leaf area and leaf biomass estimates are made and combined with local meteorological and pollution data to estimate hourly air pollution removal, total carbon storage, and annual carbon sequestration.

Results - urban forest effects

Air quality

Urban vegetation can directly and indirectly affect local and regional air quality by removing air pollution and altering the urban atmospheric environment.
Factors that affect pollution removal by trees include the amount of healthy leaf-surface area, concentrations of local pollutants, and local meteorology. In the US, urban forests are estimated to remove about 711,000 metric tons ($3.8 billion value) of air pollution per year (Nowak et al., 2006). Computer simulations using the UFORE model with local field data reveal that pollution removal by urban trees in selected cities range from 8 metric tons per year in the developed portion of Fuenlabrada, Spain, to over 1500 metric tons per year in Atlanta and New York. Amount of pollution removed was typically greatest for ozone, followed by particulate matter less than 10 um, nitrogen dioxide, sulfur dioxide, and carbon monoxide. Annual value of pollution removal, based on national median externality values for each pollutant (Murray et al., 1994), ranged from $48,000 in Fuenlabrada to $8.3 million in Atlanta.

Average annual pollution removal per square meter of canopy cover was 10.4 g, but ranged between 6.6 g/m2 in Syracuse to 27.5g/m2 in Beijing, China. Excluding Beijing, which has a relatively high pollution concentration, the average is 9.3g/m2. The average annual dollar value of pollution removed per hectare of tree cover was $552 ($508 excluding Beijing), but ranged between $378/ha cover in Syracuse to $1223/ha cover in

Beijing. **Increasing tree cover in urban areas will lead to greater pollution removal, as well as reduced air temperatures that can help improve urban air quality.**

Carbon sequestration

Trees can reduce atmospheric carbon dioxide (CO_2), the dominant greenhouse gas, by directly storing carbon (C) from CO2 as they grow. In addition, urban trees can also reduce C02 emissions from power plants by reducing building energy use by lowering temperatures and shading buildings during the summer, and by blocking winds in winter (Heisler, 1986). Healthy trees sequester carbon each year; large, healthy trees sequester about 93 kg C/yr as compared to 1 kg C/yr for small trees. Net annual sequestration by trees in the Chicago area (140,600 t C) equals the amount of carbon emitted from transportation in the Chicago area in about 1 week (Nowak, 1994).

Urban trees in the coterminous United States currently store 700 million metric tons of carbon (335 million t C to 980 million t C; $14,300 million value) with a gross carbon sequestration rate of 22.8 million t C/yr. The estimated carbon storage by urban trees in United States is equivalent to the amount of carbon emitted from US population in about 5.5 months. National annual carbon sequestration by urban trees is equivalent to US population emissions over a 5-day period (Nowak and Crane, 2002).

Stream flows and water quality

To determine the effects of urban trees on water quality, it is important to accurately quantify the effects of trees on stream flows. Urban trees affect stream flow by intercepting rainfall, transpiring water, affecting evapotranspiration of surrounding areas, and by affecting soil infiltration rates. In addition, urban trees also affect water quality by intercepting atmospheric pollutants, reducing runoff, which indirectly affects water quality, and by increasing infiltration rates in pervious areas. As trees have a relatively large impact on runoff during small frequent storm events and the most water quality control benefit is derived from the treatment of small frequent storms (Department of Irrigation and Drainage, 2000), the potential impact of urban trees on water quality is likely to be significant. To quantify the effects of urban tree and impervious surfaces on stream flow, a simulation was conducted using the UFORE-Hydro model (Wang et al., in review a, b) on the Dead Run watershed (14.3 km2) in the Baltimore, Maryland region. In the watershed, current tree cover is 13.2% with an impervious cover of 29%. Increasing tree cover in the watershed to 71 % (keeping total impervious cover at 29%) is estimated to reduce total runoff in the watershed by about 5% for the simulation period of the year 2000. Increasing impervious area from 29% to 75% (keeping tree cover at 13.2%) increased total runoff by about 50%. These results are annual effects, and variation in tree effects will occur during each season of the year. These types of data can be used to simulate the effects of changes in urban tree and impervious cover on water quality in future simulations for cities.

Urban forests and environmental programs in the United States

In the United States, there are several environmental programs or protocols where urban trees could make a contribution to improving environmental quality: State Implementation Plans (SIPS) of the Clean Air Act; Total Maximum Daily Loads (TMDL) and Stormwater Program for Municipal Separate Storm Sewer Systems of the Clean Water Act; and the Kyoto Protocols aimed at reducing greenhouse gases. The United States, although a signatory to the protocol, has neither ratified nor withdrawn from the protocol (UNFCCC, 2006a; Wikipedia, 2006).

State implementation plans

The Clean Air Act requires attainment of National Ambient Air Quality Standards (NAAQS) (US EPA, 2006a) for criteria air pollutants that cause human health impacts (e.g., ozone). Each non-attainment state must develop a state implementation plan (SIP) to attain the NAAQS by the applicable attainment deadlines. In September, 2004, the US Environmental Protection Agency (EPA) released a guidance document titled "Incorporating Emerging and Voluntary Measures in a State Implementation Plan (SIP)" ((US EPA, 2006b). This EPA guidance details how new measures, which may include ""strategic tree planting," can be incorporated in SIPS as a means to help meet air quality standards set by the EPA. Due to the new ozone standards (US EPA, 2006c)many urban areas are designated as non-attainment areas for the ozone clean air standard, and are required to reach attainment typically by 2007-2010 (but up to 2021 for Los Angeles).

As many of the standard strategies to meet clean air standards may not be sufficient to reach attainment, new and emerging strategies (e.g., tree planting, increasing surface albedo) may provide a means to help an area reach compliance with the new clean air standard for ozone. "In light of the increasing incremental cost associated with stationary source emission reductions and the difficulty of identifying additional stationary sources of emission reduction, EPA believes that it needs to encourage innovative approaches to generating emissions reductions" (US EPA, 2006b). This new emerging and voluntary measures document opens the door for urban tree programs to get credit within environmental regulations set to improve air quality (Nowak, 2005). Though this document specifically mentions trees, other environmental quality programs also have the potential to incorporate trees, though current documentation may not specifically mention trees.

Total Maximum Daily Load (TMDL) and Stormwater Program for Municipal Separate Storm Sewer Systems

A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and allocates pollutant loadings among point and non-point pollutant sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs. States should describe plans for implementing load allocations for non-point sources, including reasonable assurances that load allocations will be achieved, using incentive based, non-regulatory or regulatory approaches (US EPA, 2006d).

Storm water run-off is a leading source of water pollution and can harm surface waters such as rivers, lakes, and streams which, in turn, causes or contributes to non-attainment of water quality standards. Residential and commercial development substantially increases impervious surfaces where pollutants settle, thereby increasing runoff from city streets, driveways, parking lots, and sidewalks (US EPA, 2006e). The Stormwater Program for Municipal Separate Storm Sewer Systems is designed to reduce the amount of sediment and pollution that enters surface and ground water from storm sewer systems.

Stormwater discharges associated with Municipal Separate Storm Sewer Systems are regulated through the use of National Pollutant Discharge Elimination System (NPDES) permits (US EPA, 2006f). Through this permit, the owner or operator is required to develop a stormwater pollution prevention program that incorporates best management practices (US EPA, 2006e).

As trees can reduce stormwater flow and consequently improve water quality, urban forests have the potential to impact TMDLs and be incorporated in best management practices to reduce sediment and pollution from storm sewer systems**. Though trees have the potential to improve water quality, the magnitude of their effect must still be quantified to determine if the effects are significant enough to warrant inclusion in these programs and to identify what types/designs of tree programs are most appropriate for optimal effects on water quality in particular instances.**

Kyoto protocol

The average temperature of the earth's surface has risen by 0.6 "C since the late 1800s and is expected to increase by another 1.4-5.8 "C by the year 2100. Major contributors of carbon dioxide, a dominant greenhouse gas, are fossil fuel emissions and deforestation. Over a decade ago, most countries joined an international treaty - the United Nations Framework Convention on Climate Change - to begin to consider what can be done to reduce global warming. In 1997, governments agreed to an addition to the treaty, called the Kyoto Protocol, which has more powerful (and legally binding) measures. The Protocol entered into force on February 16, 2005 (UNFCCC, 2006b). As urban trees can both directly sequester carbon dioxide, a dominant greenhouse gas, and reduce carbon emissions from power plants, they have the potential to help reduce greenhouse gases and be incorporated with Kyoto Protocols.

Conclusion

Urban forests can improve environmental quality in urban areas. The types and magnitude of these improvements need to be accurately quantified. If vegetation effects are demonstrated to improve environmental quality, then programs/regulations designed to improve environmental quality can and should consider incorporating urban vegetation as a means to meeting established quality goals. Establishment of urban forestry programs to meet environmental quality standards can be a cost-effective "biotechnological" means to meet multiple standards (e.g., air and water quality, greenhouse gas emission reduction) as trees provide multiple benefits for a singular cost.

Note: The Kyoto Protocol is an international scale agreement that may seem irrelevant to local urban forest managers. However, many cities in the US and around the globe are in the process of adopting greenhouse gas emission control and management strategies for local implementation. As this article points out, urban forestry should be considered as a tactical measure in the development of these local strategic plans.

Picks and Shovels

Dr. Nowak's full article , "Institutionalizing urban forestry as a `biotechnology` to improve environmental quality" can be found along with other research papers at http:/ www.treesearch.fs.fed.us/

Check out the Urban Forest Effects Model (UFORE) at:
http://www.ufore.org/about/index.html

Read up on Urban Forestry and Watershed Protection at:
http://www.cwp.org/forestry/index.htm

EPA Guidance document "Incorporating Emerging and Voluntary Measures in a State Implementation Plan(SIP)" ((US EPA, 2006b). Found at:
http://www.epa.gov/ttn/oarpg/t1/memoranda/evm_ievm_g.pdf

Read the Massachusetts Climate Protection Plan at:
http://www.mass.gov/Eocd/docs/pdfs/fullcolorclimateplan.pdf

For More About Local Governments and Sustainability see:
http://www.iclei.org/index.php?id=global-about-iclei

Special Note: Due to consolidation of space and equipment within the DCR Boston office, Jane Calvin will no longer have a phone line at this location. Jane works in the Northeast of the state and can best be reached on email at urbanforestry@prospeed.net You may also contact Eric Seaborn at eric.seaborn@state.ma.us or 617-626-1468 with messages for Jane. Eric will be sure to pass them on to Jane.

Growing Greener

City of Lowell - Urban forestry is a pretty broad term. Sometimes it means protecting the canopy to let it do the work it was intended to, such as protect riparian habitat. Along the Concord River in Lowell the Lowell Parks & Conservation Trust has steadily worked to protect the 1.75 mile reach of the river as it travels through the city and into downtown, where it has its confluence with the Merrimack River. There's a beautiful glade of River Birch trees at one end and near a dam and a fish ladder there's a calm area in the river where the wood ducks may be found on their migratory path. The Trust worked with the City of Lowell to recently protect a 3 acre parcel along the river, abutting the Lowell Cemetery, a privately held oasis of historic trees overarching the gravestones of some incredible people. The Lowell Cemetery connects with Lowell's Rogers Fort Hill from which you can see Mt. Monadnock (across that continuum of community forests) and Shedd Park, some of Lowell's largest parks. Access to the river is very limited for the

neighborhoods that abut the river, because industrial owners hold much of the open space. But along this green densely canopied corridor will run the Concord River Greenway, for which the Trust has just completed 25% of the design. Creating access creates appreciation, connection and stewardship for our community natural resources - trees, rivers, ducks, and all the other species that make our city's more livable. The Trust worked with Mass Audubon a few years back to create an eco-inventory of this section of the Concord River. The inventory and other information about the site can be found at http://www.lowelllandtrust.org/Land_protection.html). You can do the same in your neck of the woods - Contact Mass Audubon's Ecological Extension Service (http://www.massaudubon.org/Nature_Connection/ees.php).

Growing on Trees

National Urban and Community Forestry Advisory Council (NUCFAC) Grants available – NUCFAC will award approximately 1 million in grant funds to projects that have a national or widespread impact and application. Grants of any dollar amount up to the 1 million dollar limit will be considered. For more information, contact Suzanne M. del Villar, Executive Assistant to the Council, at 909-585-9268 from 7am to 5pm Pacific Standard Time.

National Grid Grants: if you reside in the communities of **Douglas, Hawley, Heath, Uxbridge, Billerica, Rowe, Charlemont, Topsfield, Wenham, Norwell, Andover, Hanson, Pembroke, Wilbraham, Pepperell, Lancaster, or Haverhill** your community is eligible to access funds through the DCR – National Grid Partnership Challenge Grants funds. For more information, please visit the DCR National Grid Partnership grant section of our web site at:
http://www.mass.gov/dcr/stewardship/forestry/urban/urbanGrants.htm

Urban Tree Risk Management: A Community Guide to Program Design and Implementation: A helpful guide book that walks communities through the steps of managing risk trees and preparing for storms and other major events that may have a heavy impact on community tree cover. Copies are available by emailing a request to eric.seaborn@state.ma.us Orders are limited to one per community.

Community Inventory Guide available: Using grant funds from the DCR, the University of Massachusetts in cooperation with the City of Springfield and the USDA Forest Service has developed a booklet entitled *Community Guide: Urban and Community Forestry Inventories*. This useful guide leads communities through the steps necessary to complete a community forest inventory, covering issues including urban forestry management tools, inventory types, how to complete the inventory and many more. If you would like copies for your community or group, please contact Eric Seaborn at 617-626-1468 or eric.seaborn@state.ma.us

On The Horizon

DCR Tree Stewards Training: Our annual Tree Stewards Training Program will once again be conducted at the Harvard Forest in Petersham. The dates for the 2 day training are November 3rd and 4th. Overnight accommodations for up to 25 people are available at the Harvard Forest on a first come first served basis. Please note that, because of the lay out of the Harvard Forest buildings, you may be asked to share a room. The cost of the training is $95.00 which will include all meals and a room reservation or $45.00 to attend the training without a room reservation. Checks should be made out to **Mass ReLeaf Trust Fund**. To register for the training and to reserve a room for overnight stay, please contact Alan Snow at 413-577-2966 or alan.snow@state.ma.us

Citizen Forester of the Year: Do you work with or know someone who has demonstrated exceptional devotion to their community forest? Would you like to see that person recognized for his or her efforts? In conjunction with our annual Tree Stewards Training Program, we will be honoring Outstanding Citizen Foresters. This will the be the third year that we have presented this award that recognizes the commitment and passion of professional and volunteer community forestry managers and advocates who go above and beyond the call to care for their community resources. Please submit nominations by email to Eric Seaborn at eric.seaborn@state.ma.us The nomination should give a brief summary of the person's accomplishments and your reasons for nominating him or her for the award. **Nominations must be submitted by October 20, 2006.**

Tree City USA – It's Never Too Early to Start – A friendly reminder that Tree City USA applications and re-certification documents are due by December 31, 2006. If your community has not participated in this program in the past but you would like to try for this year, please visit the Tree City USA portion of our web site at http://www.mass.gov/dcr/stewardship/forestry/urban/urbanFAQs.htm#treeCity We are pushing toward our goal of 100 Tree Cities in the next few years and we are ready to help you attain this valuable public relations recognition award. Please contact Jane Calvin, Alan Snow or Eric Seaborn for details and assistance (contact information at the end of this newsletter).

Six Views of the Urban Forest, Lecture Series: The Lexington Tree Committee is sponsoring a series of lectures on urban and community forest issues. All events are free, made possible through a grant from DCR and will be at the Lexington Carey Library at 7:30 p.m. Contact John Frey at jwfrey2@aol.com. Series includes:

> October 18, 2006: David Pinsonneault Lexington's Superintendent of Public Grounds and Tree Warden will speak on *Implementing a Tree Management Program in Lexington*.

2004 Nobel Peace Laureate Dr. Wangari Maathai to speak in Boston: Please save the date for a unique opportunity to see and hear from one of the world's foremost community forestry advocates. Dr. Maathai will share her vision of grass roots environmental stewardship, citizen empowerment and human rights on October 24 at 7pm at Boston's historic Faneuil Hall. Information about tickets is available at www.bostonforest.org . To find out more about Dr. Maathai and the *Greenbelt Movement* that she founded in Kenya, please visit http://www.greenbeltmovement.org/

Fall 2006 Safetrees, LLC Workshop "TREE HAZARD & HABITAT". Sturbridge Host Hotel & Conference Center, 366 Main St., Sturbridge, MA. Monday, October 9, 2006. 8:30AM-4:50PM. **(Pre Announcement: save this date or register now!)** A collaborative seminar series: "International Perspectives on Tree Risk Assessment, Biomechanics, Veteran Tree Management, & Influences from the UK derived from the Study of Ancient Trees & the Aging Process". *Presenters; Ed Hayes, Safetrees, LLC, US & Neville Fay, Treework Environmental Practice* and Chairman of the Ancient Tree Forum*, UK.* For more information, contact 507-282-5739, or e-mail, ehayes@safetres.com

Empire State Green Industry Show November 14-16, 2006, Rochester Riverside Convention Center, Rochester, NY. This is a combined education conference and trade show of the New York State Arborists, ISA Chapter Inc.; New York State Turfgrass Association; New York State Nursery/Landscape Association; and New York State Flower Industries. For details, contact Jill Cyr at 518-783-1229, 800-873-8873, jill@nysta.org, or www.nysta.org.

Massachusetts Tree Wardens and Foresters Association (MTWFA) 94th Annual Conference – January 10 – 11, 2007 Host Hotel and Conference Center, Sturbridge, MA. The MTWFA is now accepting applications to exhibit at the conference in January. Please visit the MTWFA web site at www.masstreewardens.org Exhibitor reservations can be made by contacting info@masstreewardens.org or contact Karen Doherty at 413-315-3454.

Species Spotlight

***Carpinus caroliniana*, American Hornbeam**

General Description: An under story tree that grows 20'- 30' tall and just as wide in either a multi or single stem habit. Crown can be ovate to broadly columnar, with a medium to fine texture; foliage is green to blue green in summer and yellow, orange to red in fall hardy in zones 3 – 9.

Advantages and Limitations: An attractive native tree that has four season appeal: good fall color, interesting bark texture and stem form (hence the common name Muscle Wood) and a showy display of flowers in April on females. Slow growing tree that does not like exposed sites and can be challenging to transplant. This tree prefers a moist organic rich acid soil that is well drained during the growing season. Plants from southern sources are not hardy in the North. Trees suffering from transplant shock, soil compaction or poor site selection are more prone to leaf blight and twig and stem cankers that contribute to make this a short lived species.

Right Tree in the Right Place: More often used in the urban landscape as a multi stem shrub than a shade tree, the secret to success with this native is definitely Location, Location and Location. Not recommended for a tree pit but rather for sites just off the beaten path in a sheltered area with a protected and shaded root zone and ample moisture yet close enough for passersby's to admire all its attributes.

For more information and detail on cultivars visit:
http://www.hort.uconn.edu/Plants/p/plaace/plaace1.html.

The Citizen Forester is made possible through a grant from the USDA Forest Service Urban and Community Forestry Program and the Massachusetts Department of Conservation and Recreation, Bureau of Forestry.

If you have a topic or addition to the Citizen Forester newsletter, please let us know.

If you have questions about Urban and Community Forestry, contact:

Eric Seaborn, Coordinator (eric.seaborn@state.ma.us)

Jane Calvin, Community Forester, Eastern Mass
(urbanforestry@prospeed.net)

Alan Snow, Community Forester, Western Mass
(alan.snow@state.ma.us)

Bureau of Forestry
Department of Conservation and Recreation
251 Causeway Street, Suite 900
Boston, MA 02114

Mitt Romney, Governor
Kerry Healey, Lieutenant Governor
Robert W. Golledge, Jr., Secretary, Executive Office of Environmental Affairs
Stephen H. Burrington, Commissioner, Department of Conservation and Recreation
Jim DiMaio, Chief, Bureaus of Forest Fire Control and Forestry